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Frazier et al.

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[45] Date of Patent: Jan. 13, 1998

[54] **BAG NECK GATHERING STOP**

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[73] Assignee: **Burford Corporation**, Maysville, Okla.

[21] Appl. No.: **583,567**

[22] Filed: **Jan. 5, 1996**

Related U.S. Application Data

[62] Division of Ser. No. 129,284, Sep. 30, 1993, Pat. No. 5,483,134.

[51] **Int. Cl.**[6] **G05B 5/00**

[52] **U.S. Cl.** **318/468**; 318/626; 318/364; 53/138.8; 53/583

[58] **Field of Search** 53/138.1–138.3, 53/138.6–138.8, 139.4, 203, 583; 318/560–1, 567, 568.1, 569, 626, 445, 449–450, 466–470, 362, 364, 365

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,059,670	10/1962	Burford et al. .	
3,138,904	6/1964	Burford .	
3,583,131	6/1971	Gaudlitz	53/135
3,648,432	3/1972	Zellmer et al.	53/135
3,721,061	3/1973	Bodolay	53/135
3,825,039	7/1974	Crabb	53/138 A
3,919,829	11/1975	Burford et al.	53/135
4,277,731	7/1981	Pongracz .	
4,537,005	8/1985	Hoyland	53/131
4,586,412	5/1986	Johnson	53/71
4,730,434	3/1988	Knudsen	53/67
4,856,258	8/1989	Burford et al.	53/138 A
4,868,759	9/1989	Ross et al.	53/51
5,121,682	6/1992	Parker et al.	53/138.8
5,138,815	8/1992	Groschen, Jr.	53/55
5,194,793	3/1993	Niimi	318/568.15
5,347,791	9/1994	Ginzl et al.	53/450
5,483,134	1/1996	Frazier et al.	318/468

OTHER PUBLICATIONS

Motorola, MC68332 SIM User's Manual ©Motorola Inc., 1989.

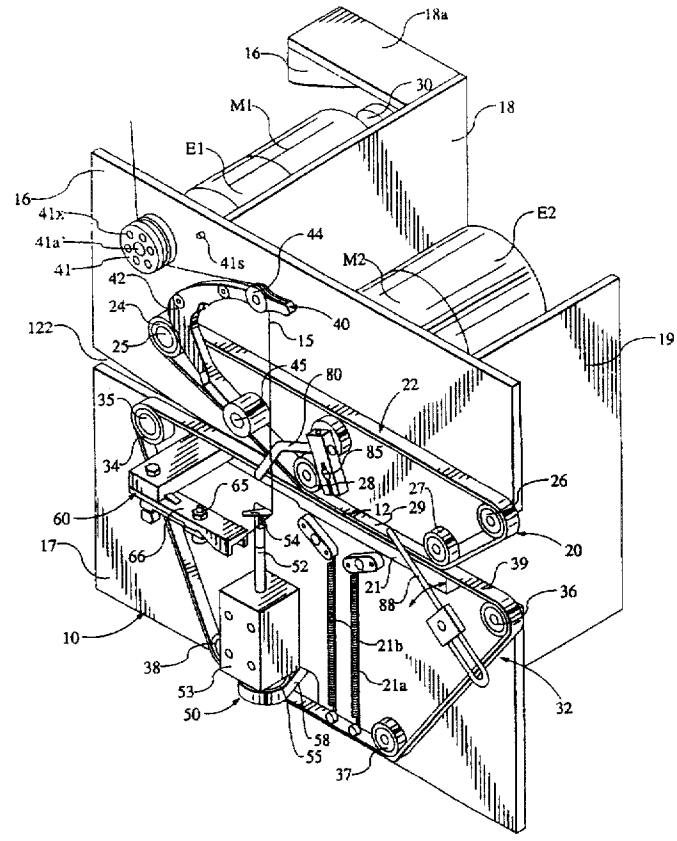
Hewlett Packard, 56mm Diameter Two and Three Channel Incremental Optical Encoder Kit, HEDS–6000 Series pp. 1–8 (Pub. No. 5954–8420, Mar. 1987).

Primary Examiner—David S. Martin
Attorney, Agent, or Firm—Crutsinger & Booth

[57] **ABSTRACT**

A bag neck tying device for tying a ribbon dispensed from a spool about a gathered neck. A pulley and proximity switch are mounted to prevent the completion of a tying cycle if a bag neck is not properly gathered and ready to be tied.

11 Claims, 13 Drawing Sheets



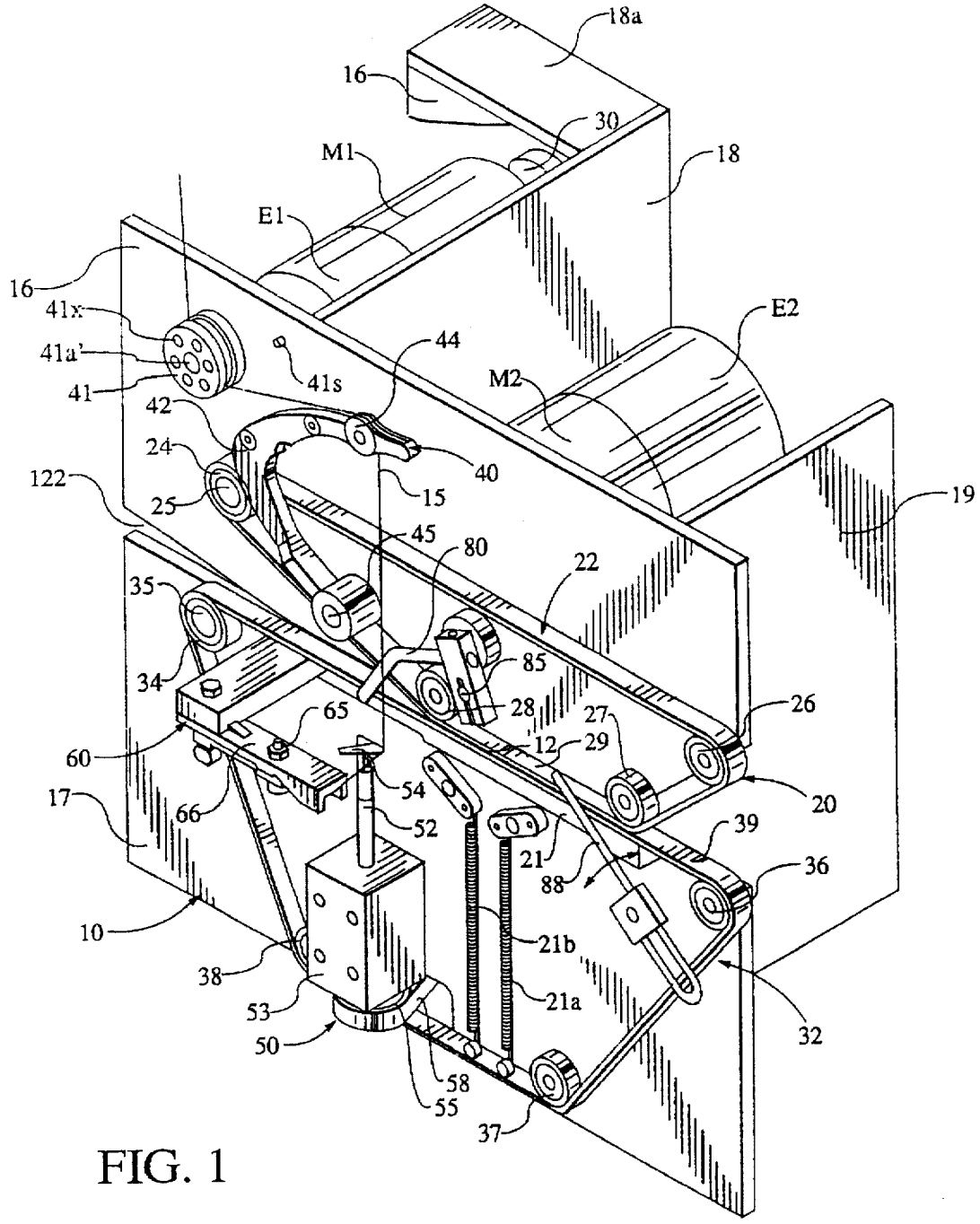

18a
16
30
M1
18
E1
16
41x
41a'
41
41s
44
42
M2
E2
24
40
122
25
15
19
45
80
22
35
85
34
28
27
26
65
12
29
60
54
20
17
66
52
39
21
88
36
10
21b
38
21a
53
32
50
58
55
37

FIG. 1

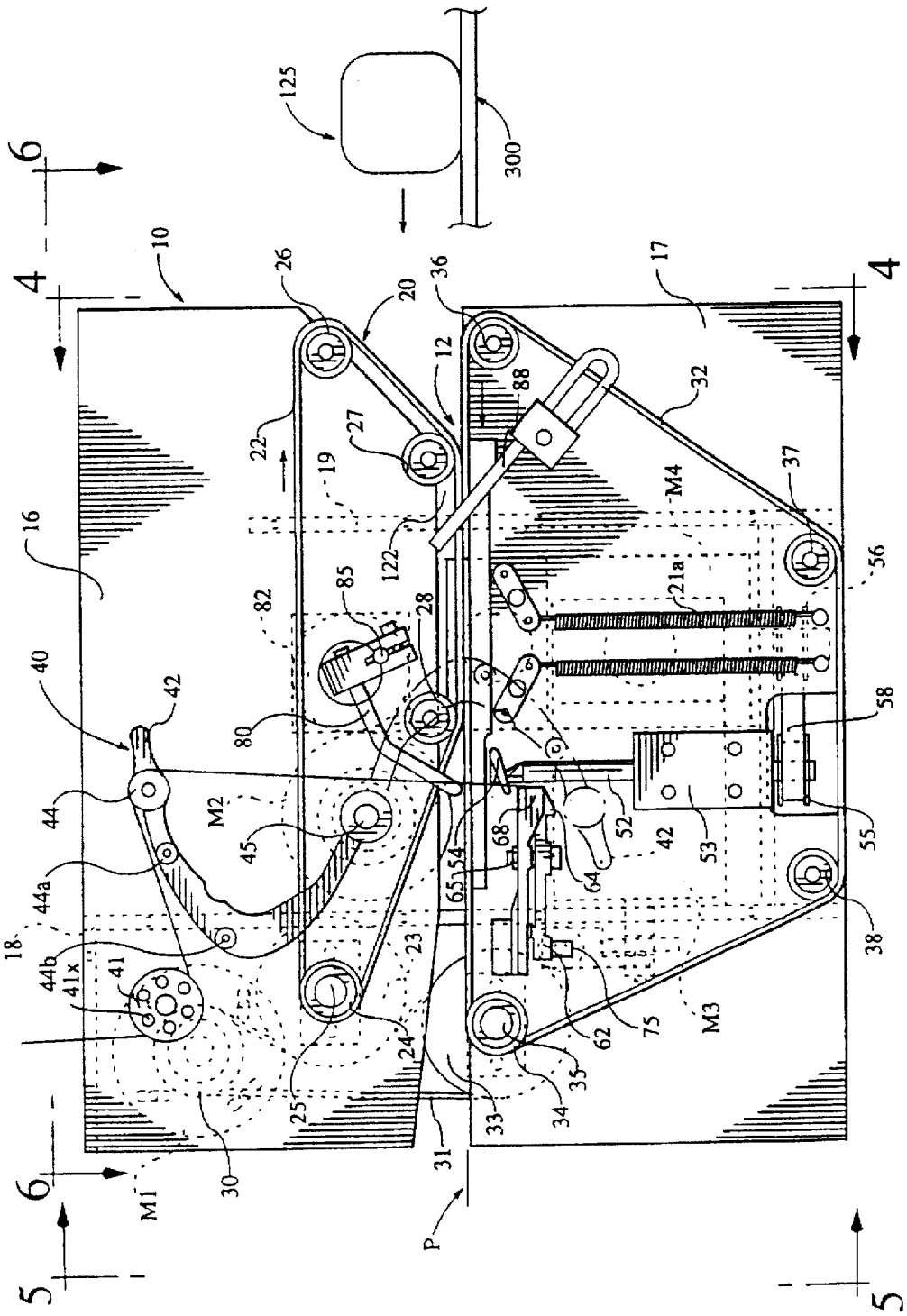

125
300
6
4
10
26
20
36
17
12
88
32
22
27
19
M4
37
16
122
85
28
21a
56
82
80
42
40
58
44
M2
45
68
52
42
53
55
44a
54
65
64
18
23
38
44b
41x
41
24
62
75
M3
35
25
33
34
31
30
M1
P
5

FIG. 2

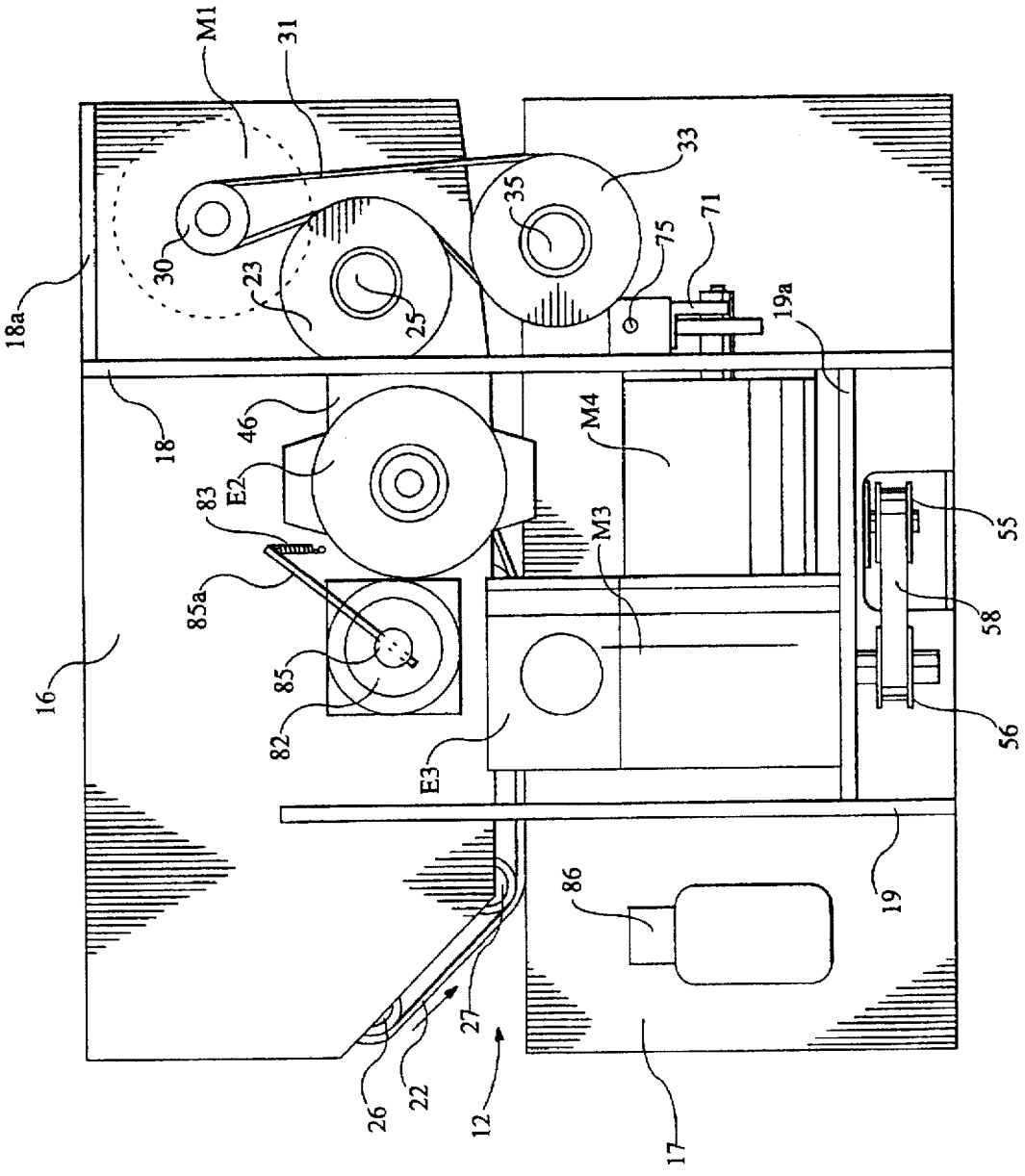

M1
31
33
35
71
75
30
23
25
18a
19a
18
46
M4
E2
83
M3
55
85a
58
16
85
56
82
E3
19
86
27
26
22
12
17

FIG. 3

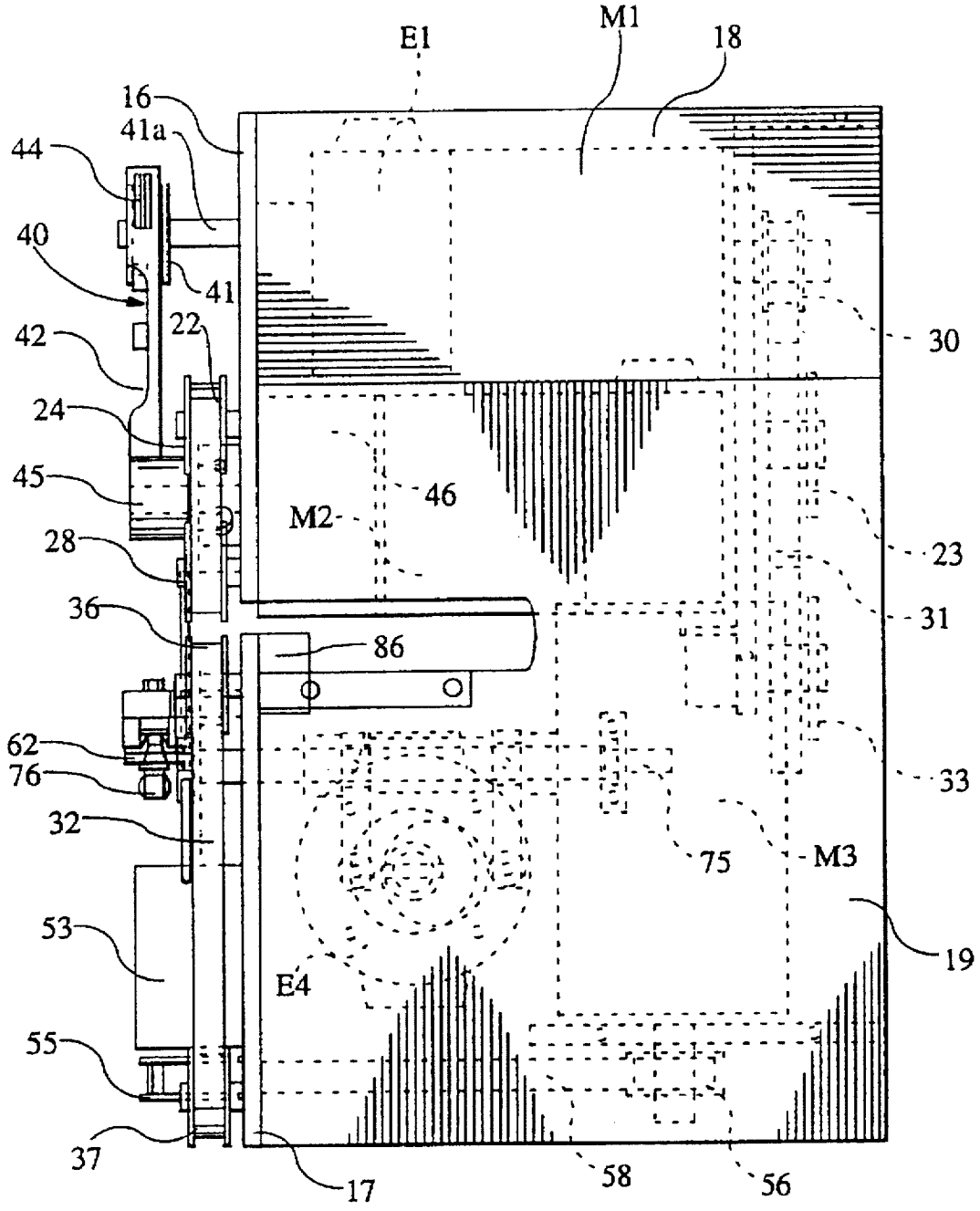

E1
M1
18
16
41a
44
40
41
22
42
24
45
28
36
62
76
32
53
55
37
17
58
56
E4
75
M3
19
33
31
23
30
M2
46
86

FIG. 4

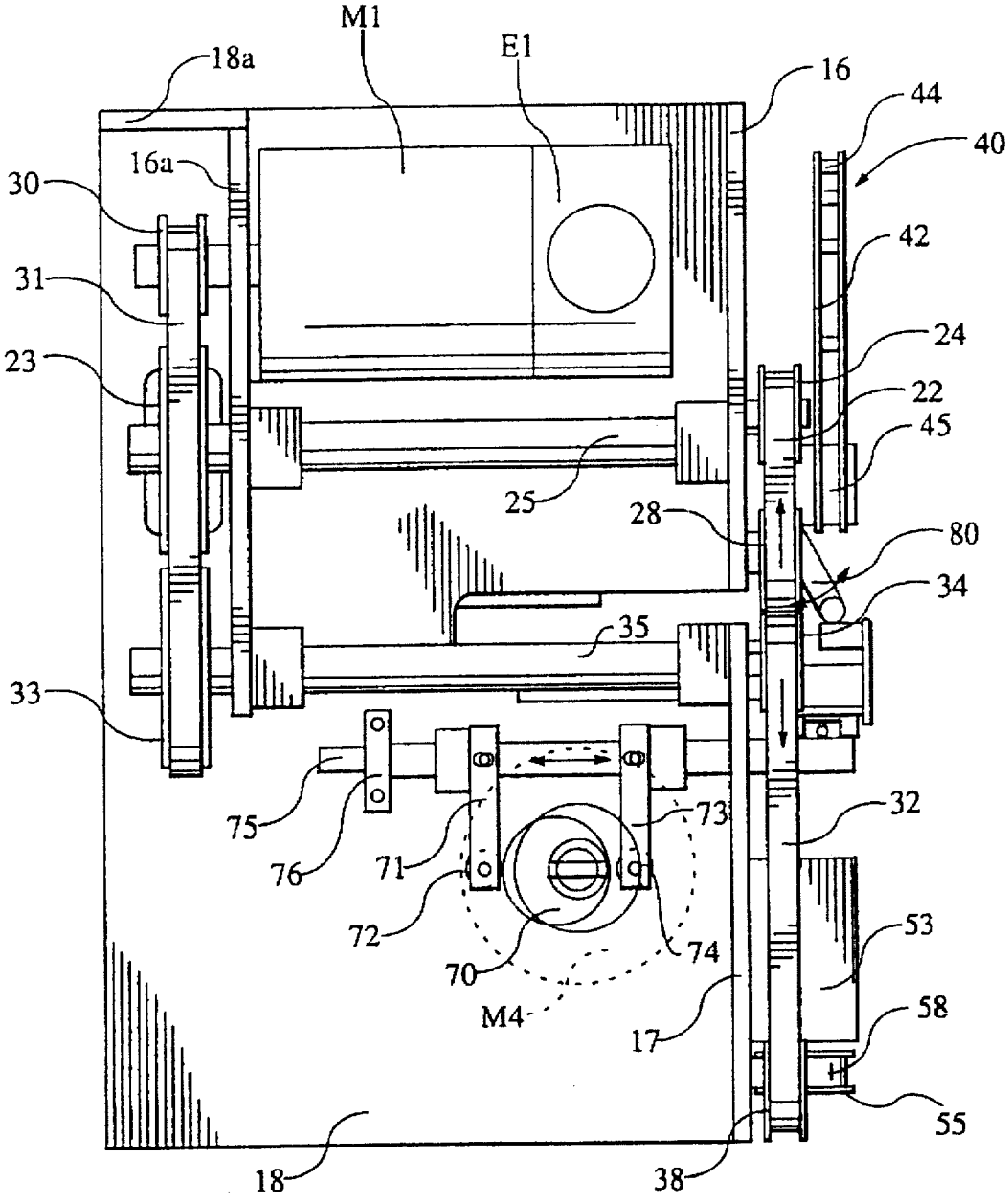

M1
E1
18a
16
44
40
16a
30
42
31
24
23
22
45
25
28
80
34
35
33
32
75
73
76
71
72
74
70
53
M4
58
17
55
18
38

FIG. 5

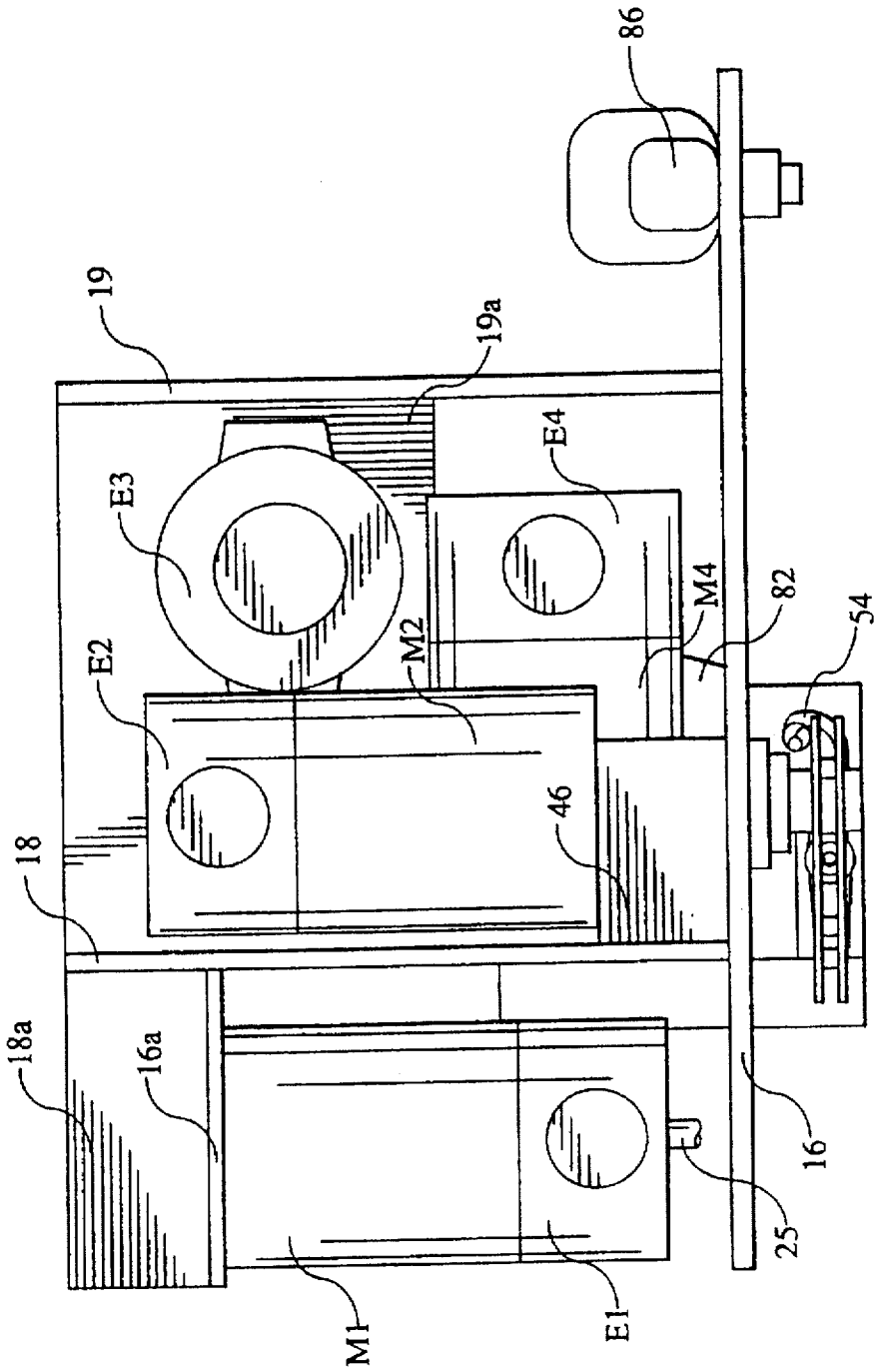
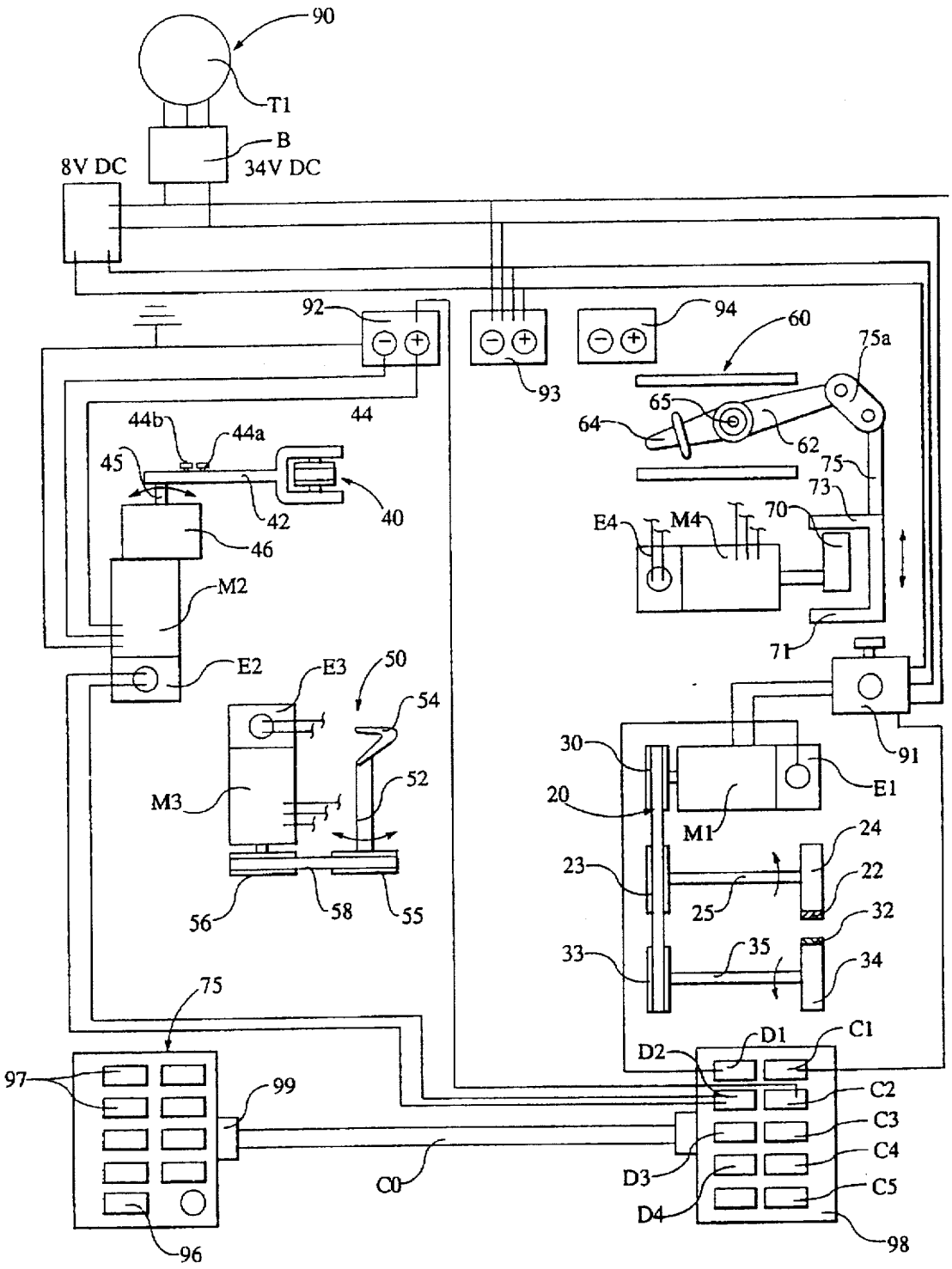


FIG. 6


90
T1
B
8V DC
34V DC
92
94
60
75a
93
44
65
64
62
75
73
44b
44a
45
42
40
70
E4
M4
46
M2
71
E2
E3
50
54
91
30
E1
M3
52
20
M1
24
23
22
25
32
33
35
34
56
58
55
75
D1
C1
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C2
C3
C4
C0
D3
C5
D4
96
98

FIG. 7

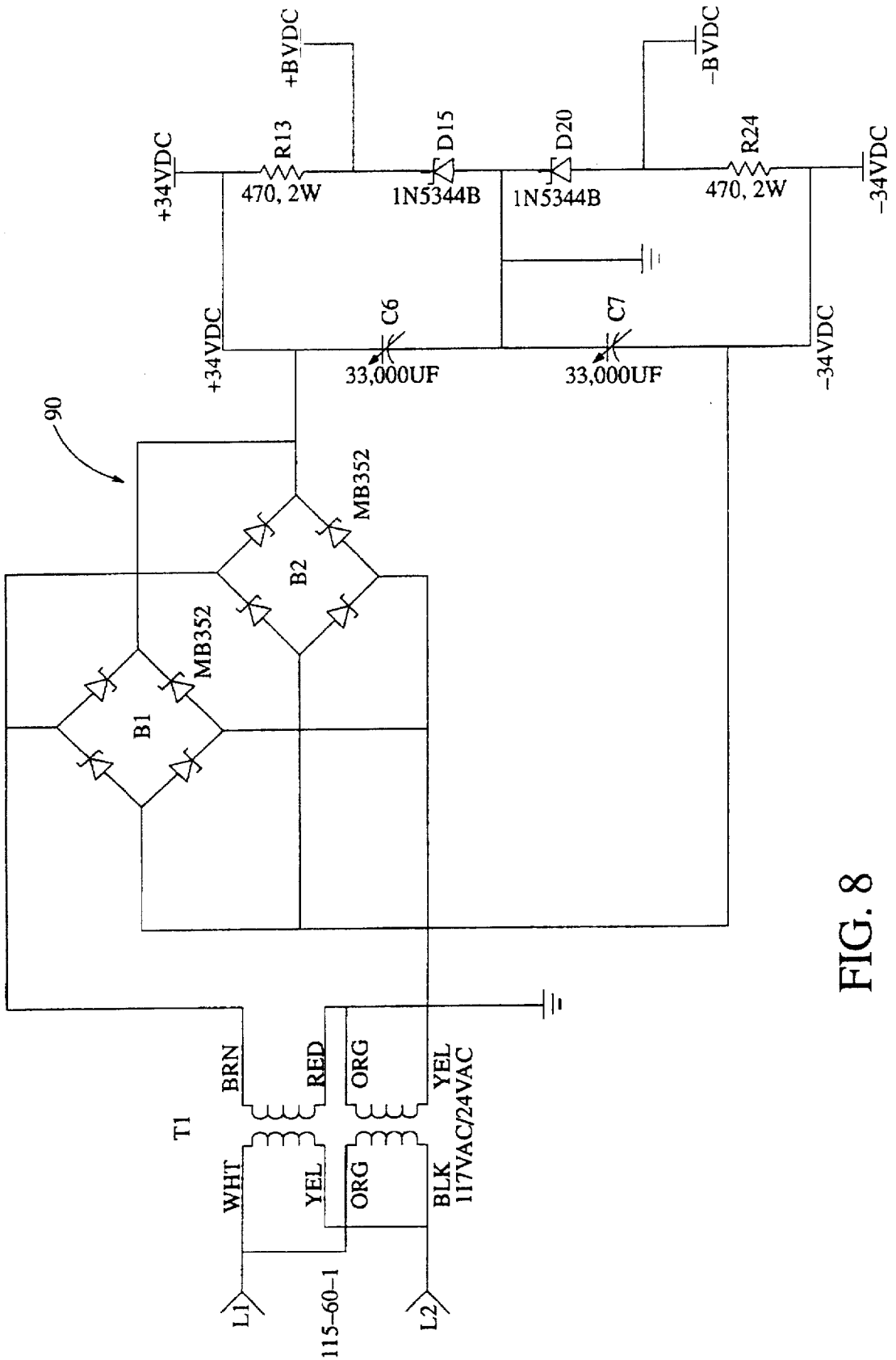
+BVDC
-BVDC
+34VDC
R13
470, 2W
D15
1N5344B
D20
1N5344B
R24
470, 2W
-34VDC
+34VDC
C6
33,000UF
C7
33,000UF
-34VDC
90
MB352
B2
MB352
B1
T1
BRN
RED
ORG
YEL
WHT
YEL
ORG
BLK
117VAC/24VAC
L1
115-60-1
L2

FIG. 8

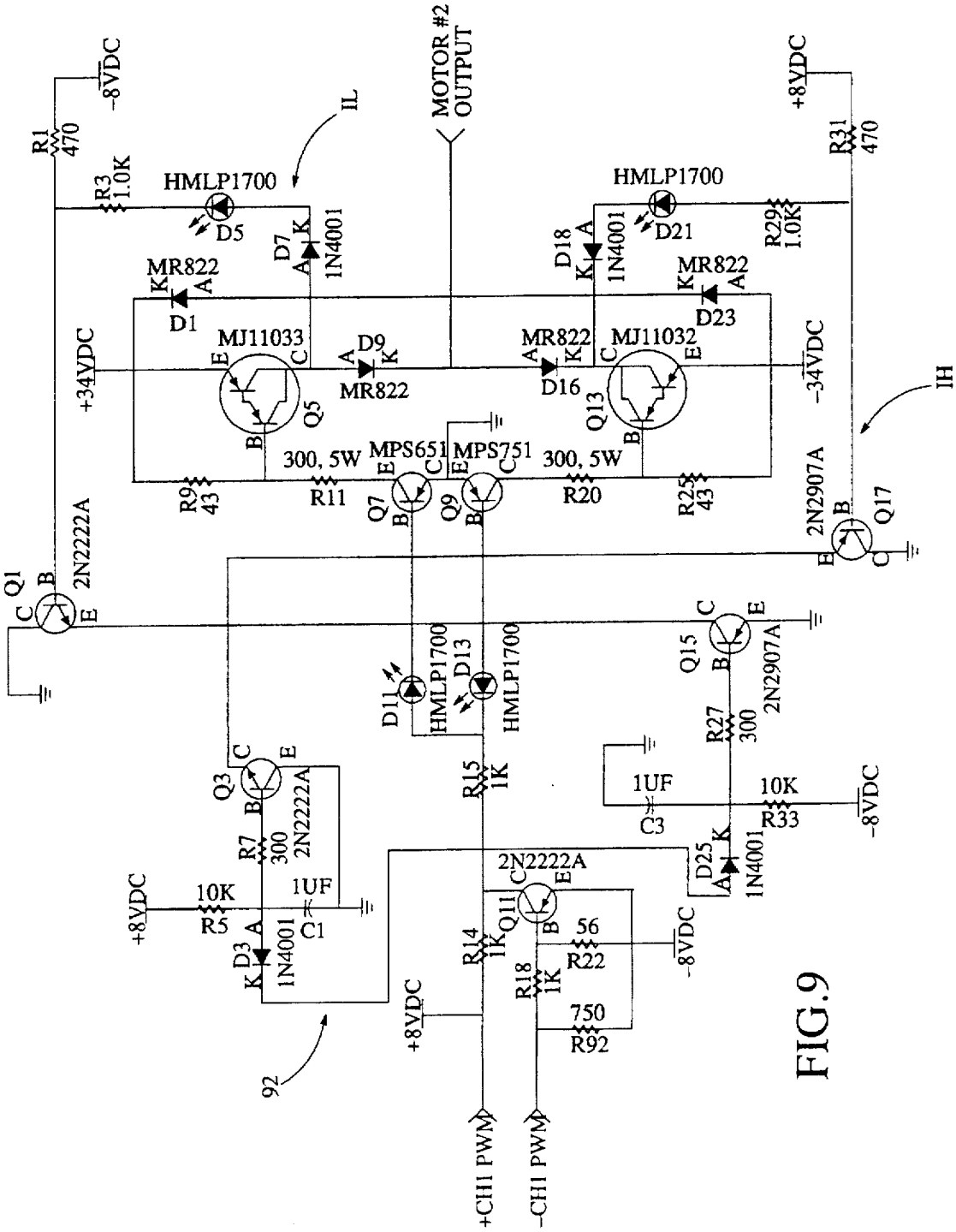
MOTOR #2 OUTPUT
IL
IH
-8VDC
+8VDC
+34VDC
-34VDC
R1 470
R3 1.0K
R31 470
R29 1.0K
HMLP1700
D5
D21
D7 1N4001
D18 1N4001
MR822
D1
D23
MJ11033
MJ11032
Q5
Q13
D9
D16
300, 5W
MPS651
MPS751
R9 43
R11
R20
R25 43
Q7
Q9
2N2907A
Q17
2N2222A
Q1
D11
D13
Q15
R27 300
R15 1K
Q3
R7 300
1UF
C3
10K
R33
D25 1N4001
C1
R5
D3 1N4001
2N2222A
Q11
R14 1K
R18 1K
56
R22
750
R92
92
+CH1 PWM
-CH1 PWM

FIG.9

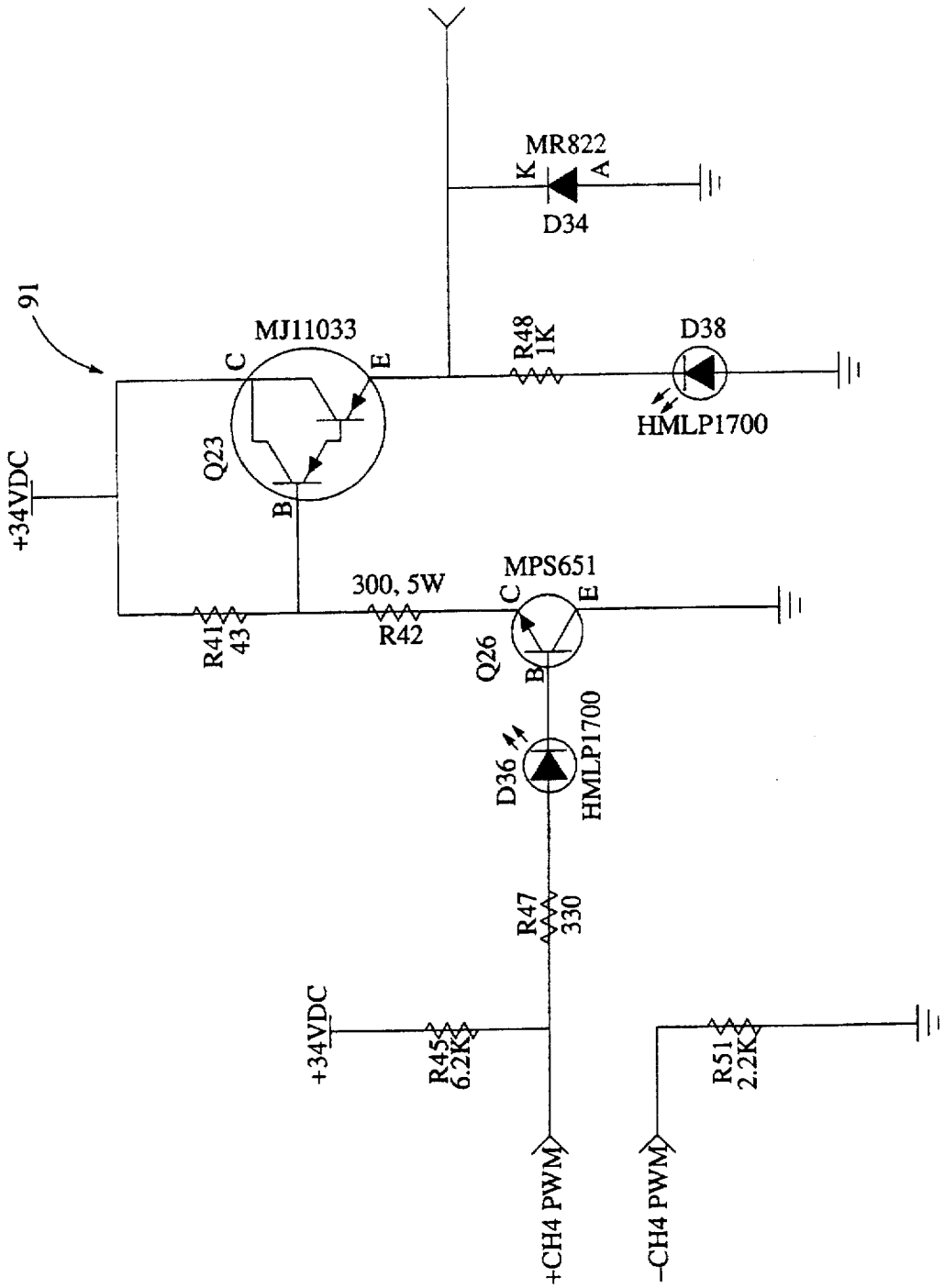
MR822
K
A
D34
91
MJ11033
C
E
B
Q23
R48
1K
D38
HMLP1700
+34VDC
300, 5W
MPS651
C
E
B
Q26
R41
43
R42
D36
HMLP1700
R47
330
+34VDC
R45
6.2K
R51
2.2K
+CH4 PWM
-CH4 PWM

FIG. 10

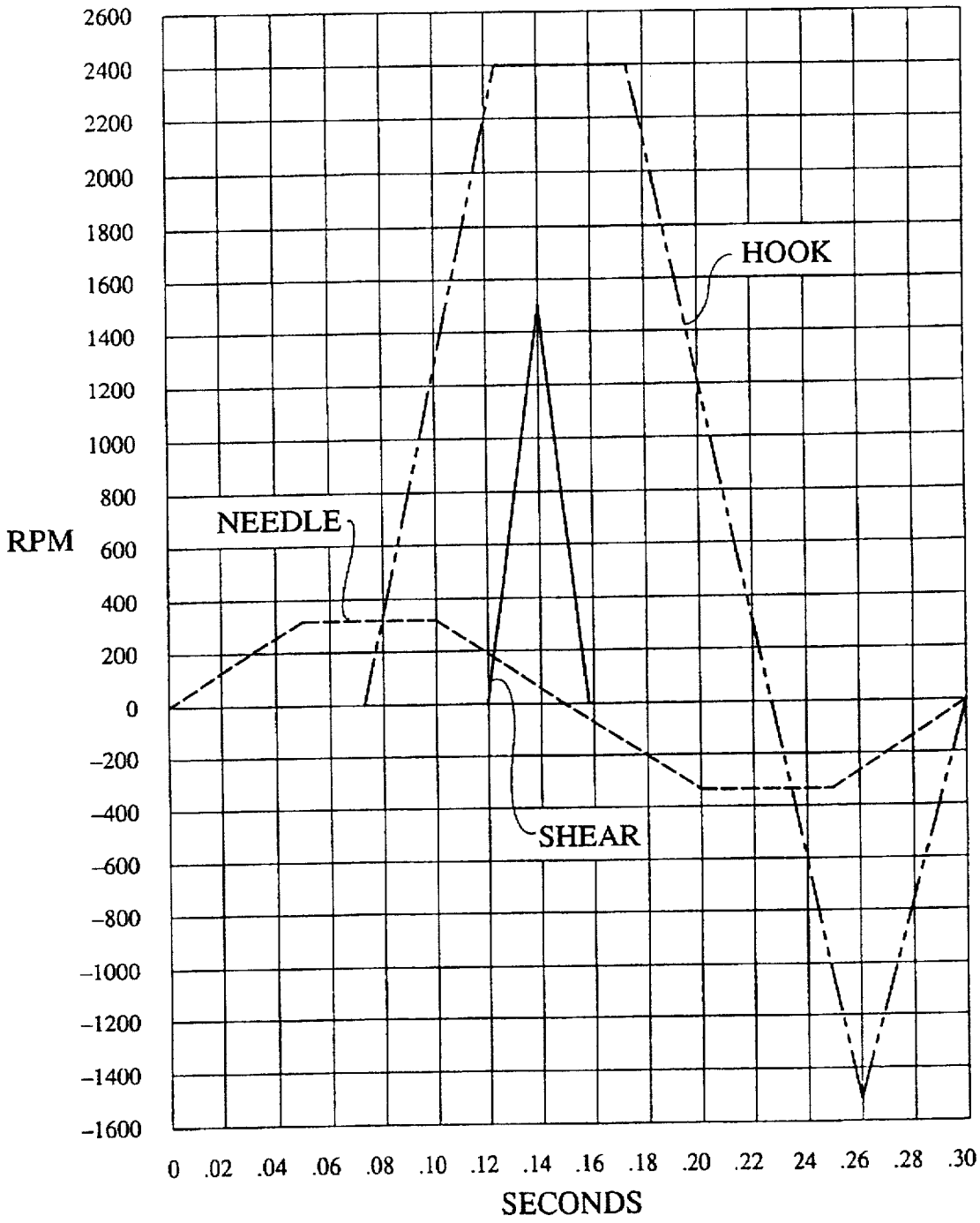
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
RPM
HOOK
NEEDLE
SHEAR
0 .02 .04 .06 .08 .10 .12 .14 .16 .18 .20 .22 24 .26 .28 .30
SECONDS

FIG. 11

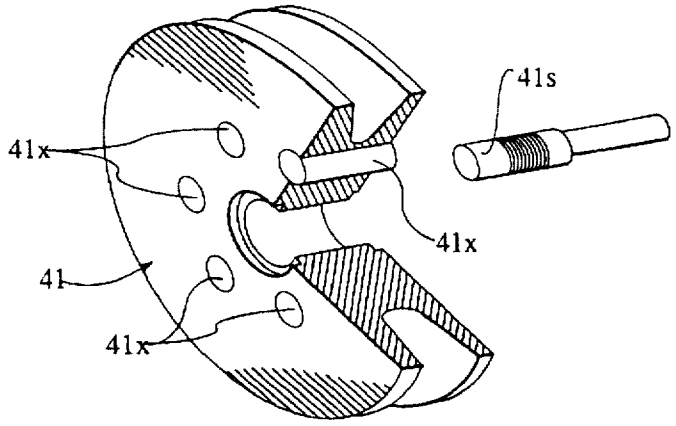
41s
41x
41x
41
41x

FIG. 13

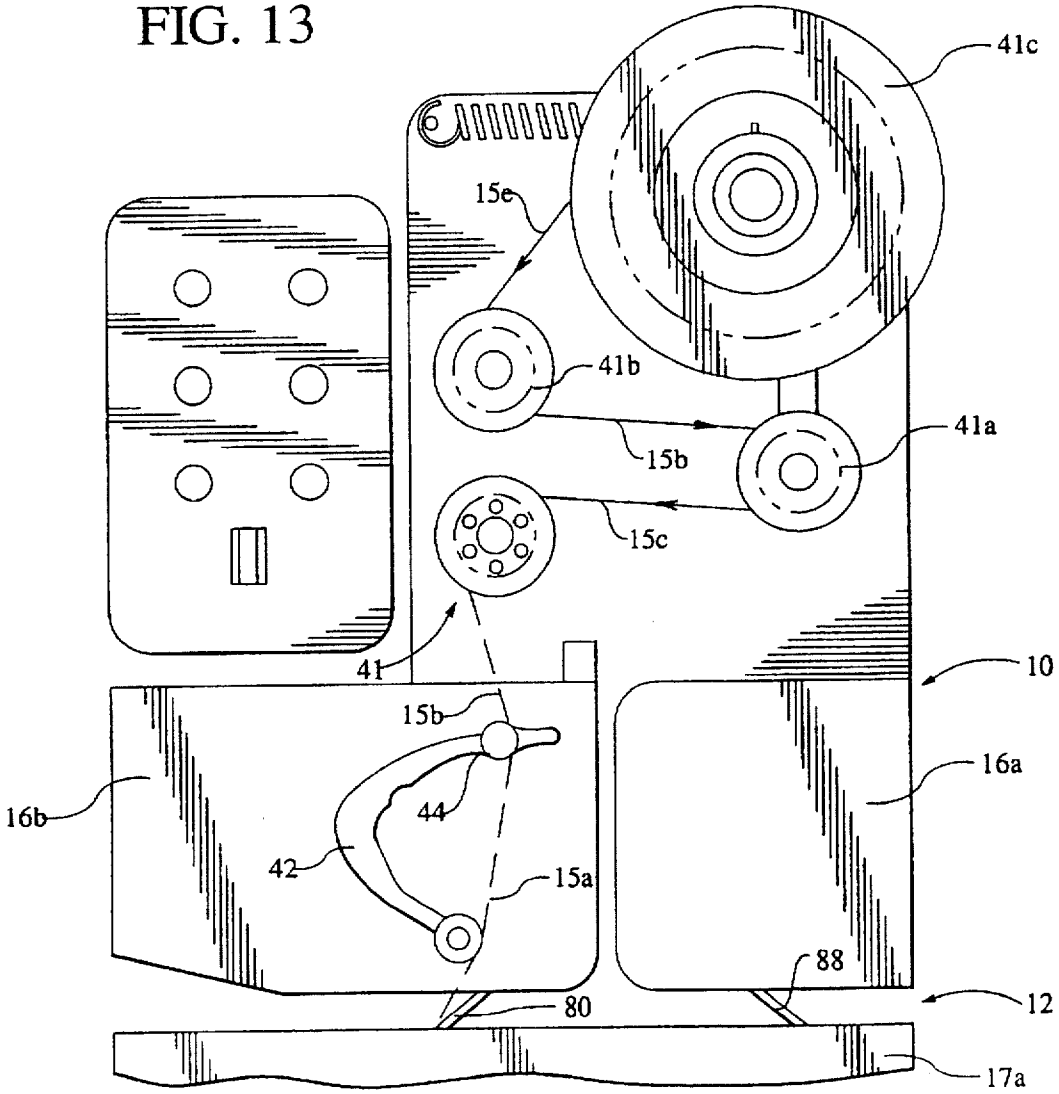
41c
15e
41b
41a
15b
15c
41
10
15b
16a
16b
44
42
15a
88
80
12
17a

FIG. 12

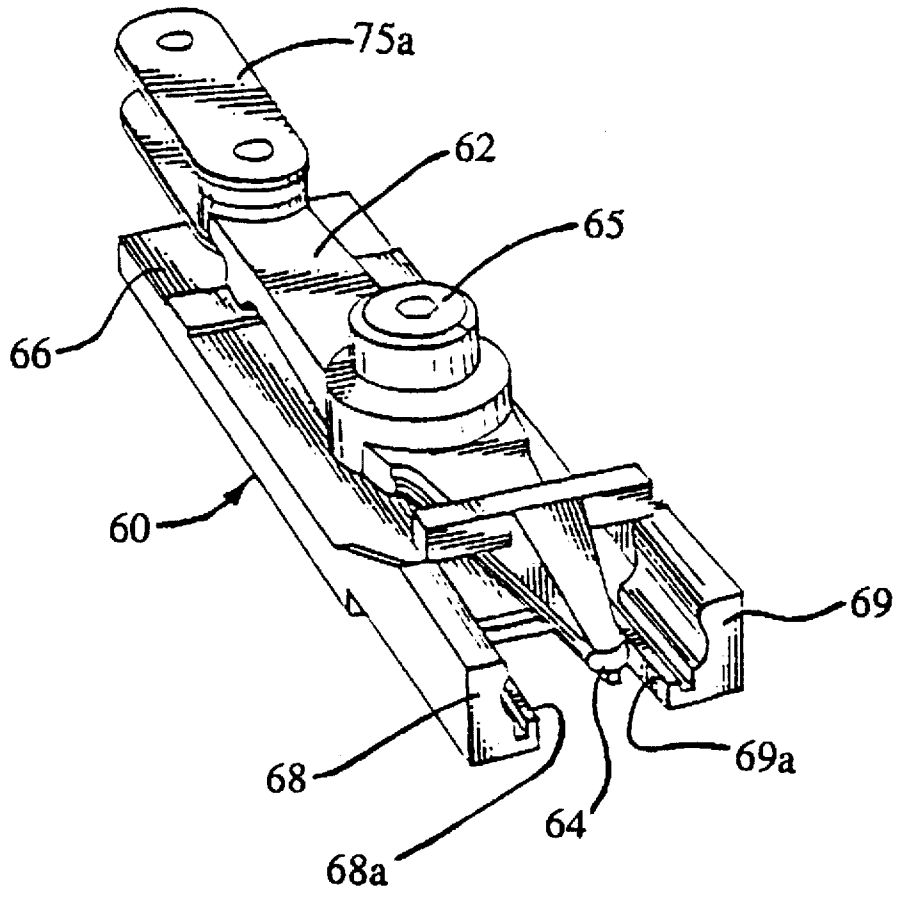

FIG. 14

BAG NECK GATHERING STOP

This is a division of application Ser. No. 08/129,284 filed Sep. 30, 1993 now U.S. Pat. No. 5,483,134.

TECHNICAL FIELD

The invention relates to apparatus for wrapping a ribbon around the gathered neck of a bag and twisting the ribbon for closing and sealing the neck of a flexible bag.

BACKGROUND OF INVENTION

U.S. Pat. No. 3,138,904 to Earl E. Burford entitled "METHOD AND APPARATUS FOR TYING PACKAGES AND WRAPPING MATERIALS;" U.S. Pat. No. 3,059,670 to Charles E. Burford and Leonard W. Burford entitled "WIRE TWISTING TOOL;" U.S. Pat. No. 3,919,829 to Leonard W. Burford and Charles C Burford entitled "APPARATUS FOR TYING PACKAGES AND WRAPPING MATERIALS;" and U.S. Pat. No. 4,856,258, which issued Aug. 15, 1989 to Charles E. Burford and Jimmy R. Frazier entitled "WIRE TYING DEVICE" disclose apparatus used for closing a plastic bag by attaching and twisting a wire-like ribbon about the neck of the bag.

Bag tying devices of the type disclosed in the aforementioned patents are commercially available from Burford Corporation of Maysville, Okla. The tying devices are generally constructed to receive packages such as loaves of bread at speeds of for example one hundred (100) packages per minute. The design of the bag tying devices requires careful consideration of the mass, acceleration, deceleration and momentum of the moving parts of the tying device. Further, precise synchronization of paris in subassemblies of the tying devices must be maintained throughout a tying cycle if the device is to operate effectively.

SUMMARY OF INVENTION

The bag neck tying device disclosed herein incorporates a bag neck gathering mechanism comprising motor driven gathering belts for moving a bag neck along a path in a plane into engagement with a bag stop controlled by an electric brake positioned adjacent a ribbon holder-shear assembly which holds the free end of a ribbon of He material. A motor driven needle wraps the strand of tie material around the gathered neck of the bag, and a motor driven twister hook assembly engages the free end and the running end of the ribbon adjacent the gathered neck for twisting the ribbon.

Independently controlled bi-directional, brush type servomotors are mounted in the separate subassemblies of the tying device. Each of the servomotors is controlled by a solid state DC motor controller in a closed loop feedback system under the control of a multi-channel microcontroller which precisely starts, controls and stops each of the servomotors in a pre-assigned sequence for each cycle of the tying apparatus.

The weight and number of moving parts in the tying device have been significantly reduced. More particularly, the software driven motor controllers isolate the movement of the various components of the tying device to reduce stress and shock loading of parts of mechanical drive trains.

A preferred embodiment of the apparatus for securing material includes improvements in apparatus for gathering material, such as plastic bag material or a variety of other materials such as coils of electrical cord, water hose, tubing, yarn, and bundles of cable, rods, or carrots, and in apparatus for fastening the gathered material. It is contemplated that the disclosed closed loop control circuit may be used to control electric motors to drive apparatus for fastening gathered materials in addition to the specific disclosed embodiment of the bag neck tying device.

DESCRIPTION OF THE DRAWINGS

Drawings of a preferred embodiment of the invention are annexed hereto so that the invention may be better and more fully understood, in which:

FIG. **1** is a perspective view illustrating the front of the bag neck tying device;

FIG. **2** is a diagrammatic front elevational view;

FIG. **3** is a diagrammatic rear elevational view;

FIG. **4** is an end view looking generally in the direction of the arrows along line **4—4** in FIG. **2**;

FIG. **5** is a diagrammatic end view illustrating the discharge end of the bag neck tying device, looking in the direction of the arrows along line **5—5** in FIG. **2**;

FIG. **6** is a top plan view, looking in the direction of the arrows along line **6—6** in FIG. **2**, parts being broken away to more clearly illustrate the details of construction;

FIG. **7** is a wiring diagram of the closed loop microcomputer controlled control system;

FIG. **8** is a schematic diagram of the full wave rectified 8 and 34 volt power supply;

FIG. **9** is a schematic diagram of a bi-directional DC motor controller;

FIG. **10** is a schematic diagram of a single direction DC motor controller;

FIG. **11** is a graphic representation of the sequence of operation of the needle, hook and shear assemblies during a complete cycle of operation;

FIG. **12** is a diagramatic front elevational view of the tying device with belt guards and covers in position, illustrating a spool of ribbon;

FIG. **13** is a diagramatic perspective view of a pulley and proximity switch; and

FIG. **14** is a perspective view of a holder-shear assembly.

Numeral references are employed to designate like parts throughout the various Figures of the drawing.

DESCRIPTION OF A PREFERRED EMBODIMENT

The wire tying device, generally designated by the numeral **10**, in FIGS. **1** and **2** of the drawing is mounted adjacent the side of a conveyor **300** of the type disclosed in Burford U.S. Pat. No. 3,138,904 and Burford U.S. Pat. No. 3,919,829, the disclosures of which are incorporated herein by reference in their entirety for all purposes. Conveyor **300** carries for example, loaves **125** of bread to, through and out of wire tying device **10** in rapid succession. Conveyor **300** is well known to persons skilled in the art and further description thereof is not deemed necessary except in connection with the drive mechanism as will be hereinafter more fully explained. It should be appreciated that other and further structures may form the conveyor.

Referring to FIG. **1** of the drawing, the numeral **20** generally designates a bag gathering apparatus for moving a bag **125** along a path **12** to a position adjacent a needle assembly **40**, a twister hook assembly **50** and a holder-shear assembly **60**. As will be hereinafter more fully explained, the free end of a ribbon of wire-like material **15** is gripped in holder-shear assembly **60**. The neck of the bag moves

through a slot **122** between upper face plate **16** and lower face plate **17** for drawing the bag **125** to a controlled tension about the contents thereof. Needle assembly **40** wraps the ribbon **15** of the wire-like material about the gathered neck of the bag and twister hook **50** is actuated for twisting a portion of the wire-like material about the neck of the bag **125**. It should be noted that the ribbon of material **15** may be constructed of wire enclosed in paper or plastic or it may comprise a ribbon of plastic or any other material. The strand of ribbon **15** extends around one or more pulleys **41**, **41***a* and **41***b* mounted on shafts **41***a*' from a spool **41***c* of tie material, as best illustrated in FIG. **12**.

The mounting for spool **41***c* is similar to that disclosed in U.S. Pat. No. 3,919,829 entitled "APPARATUS FOR TYING PACKAGES AND WRAPPING MATERIALS", the disclosure of which is incorporated herein by reference in its entirety for all purposes. However, it will be noted that spool **41***c* of tie material is mounted on a shaft and tie material **15** is fed from spool, **14***c* and is routed around wilers **41***b*, **41***a* and **41**, around needle roller **44** and the end of the ribbon **15** is gripped in the holder-shear assembly **60**, as best illustrated in FIGS. **1** and **14** of the drawing. Spool **41***c* is mounted on a shaft engaged by a brake (not shown). As needle **42** forms a loop of tie material around the gathered neck of a bag, the force of inertia and force exerted by the brake cause the spool **41***c* to remain stationary momentarily as a crank arm, on which roller **41***a* is mounted, is rotated in a clockwise direction as illustrated in FIG. **12** of the drawing.

As will be hereinafter more fully explained, one of the pulleys **41**, **41***a* or **41***b* is preferably equipped with a sensor device which is capable of calculating the amount of ribbon **15** dispensed from spool **41***c*. The sensor apparatus determines whether or not a bag neck is present. As needle **41** moves from the full outline position illustrated in FIG. **2** to the dashed outline position, if a bag neck is not positioned in the path of the ribbon, the cycle of operation will be interrupted so that the holder-shear assembly **60** will not be actuated and the twister hook assembly **50** will not rotate. This prevents actuation of the holder-shear assembly which would have resulted in the ribbon being dropped or released if a bag neck was not present.

The frame of the bag tying device may assume many configurations. In the illustrated embodiment upper and lower face plates **16** and **17** are supported on forward edges of vertically extending end plates **18** and **19** having slots formed therein to permit passage of a bag neck. A horizontal mounting plate **19***a* extends between lower portions of end plates **18** and **19** and a vertical mounting plate **16***a* extends outwardly from end plate **18**.

A motor **M1**, having an encoder **E1** mounted the rear end of motor **M1**, is mounted on an upper portion of the vertical mounting plate **16***a* for driving the gathering assembly **20**. A motor **M2**, having an encoder **E2** mounted the rear end and a gear box **46** mounted on the front end of motor **M2**, is mounted on an upper portion of the rear surface of face plate **16** for driving the needle assembly **40**. A motor **M3**, having an encoder **E3** mounted the rear end of motor **M3**, is mounted vertically on horizontally extending mounting plate **19***a* for driving the twister hook assembly **50**. A motor **M4**, having an encoder **E4** mounted the rear end of motor **M4**, is mounted on a lower portion of end plate **18**, and in the illustrated embodiment extends below motor **M2**, for driving the holder-shear assembly **60**.

Referring to FIGS. **1–5** of the drawing, bag neck gathering apparatus **20** comprises, in a preferred embodiment of the invention, an upper gathering belt **22** routed around a driven pulley **24** and idler pulleys **26**, **27** and **28**. The bag neck gathering mechanism **20** further comprises a lower gathering belt **32** routed around a driven pulley **34** and idler pulleys **36**, **37** and **38**. As best illustrated in FIG. **1** of the drawing the portion **29** of the upper gathering belt **22**, extending between idler pulleys **27** and **28**, is substantially parallel and closely spaced relative to the portion **39** of the lower gathering belt **32** which extends between driven pulley **34** and idler pulley **36**. In the illustrated embodiment, gathering belts **22** gand **32** move a bag neck along path **12** in a plane P as illustrated in FIG. **2**. A pressure pad **21**, resiliently urged upwardly by springs **21***a* and **21***b* acting through bell cranks, maintains belts **22** and **32** in frictional engagement with the neck of a bag or other material to be tied.

As best illustrated in FIGS. **3** and **5** of the drawing, driven shaft **25**, having driven pulley **24** mounted on one end, has a pulley **23** mounted on its opposite end. Driven shaft **35**, having driven pulley **34** mounted on one end, has a pulley **33** mounted on its opposite end. A pulley **30** mounted on the drive shaft of motor **M1** drives pulleys **23** and **33** through a belt **31** such that driven pulley **24** rotates in a clockwise direction while driven pulley **34** rotates in a counter-clockwise direction, as viewed in FIG. **2** of the drawing. Belt guards **16***a* and **16***b* and **17***a* preferably extend between the gathering belts and products on the conveyor, as illustrated in FIG. **12**. The bag neck is moved into a slot in the belt guard by brushes (not shown) and the product in the bag engages the belt guards when the neck of the bag is drawn by gathering belts **22** and **32** around a bag stop lever **80**. It should be appreciated that other and further gathering structures may be used to form a gathered neck on a bag.

Terms such as "left," "right," "clockwise," "counter-clockwise," "horizontal," "vertical," "up," and "down" when used in reference to the drawings, generally refer to orientation of the parts in the illustrated embodiment and not necessarily during use. These terms used herein arc meant only to refer to relative positions and/or orientations, for convenience, and are not to be understood to be in any manner otherwise limiting.

As illustrated in FIGS. **7** and **10** of the drawing motor **M1** is driven by a solid state DC motor controller **91** which is capable of varying the speed of motor **M1** to substantially synchronize movement of upper gathering belt **22** and lowering gathering belt **33** with the speed of a conveyor **300** moving packages **125** adjacent the bag gathering mechanism **20**. For example, if the tier **10** is to gather and tie the necks of 100 bags per minute, the conveyer **300** would preferably bring bags to and through the tier at a speed of approximately 300 feet per minute and the gathering belts **22** and **32** would preferably be driven at a speed of, for example **305** feet per minute, so that the neck of the bag would be accelerated for gathering the neck, stopped momentarily while it is being tied with a ribbon and then discharged in a substantially continuous operation.

As will hereinafter be more fully explained, the gathering assembly **20** also includes a bag stop lever **80**, illustrated in FIGS. **2** and **3**, mounted on shaft **85** for rotary movement about a horizontal axis, in the illustrated embodiment. Shaft **85** extends through an electric brake **82**, which momentarily locks lever **80** in a lowered position extending across path **12** such that gathering belts **22** and **32** move the bag neck into engagement with lever **80**. After the bag neck has been gathered and tied, the electric brake **82** is released and the gathered neck, carried between belts **22** and **32**, urges the lever **80** upwardly such that it does not obstruct movement

of the gathered neck. After the gathered neck passes lever **80**, the lever **80** moves back to the illustrated position extending across path **12**.

A needle assembly **40**, best illustrated in FIGS. **1–4** and **7**, is positioned for wrapping a strand **15** of ribbon material around a gathered neck of a bag. The needle assembly **40** comprises a needle **42** carrying idler rollers **44**, **44***a* and **44***b*. The needle **42** is mounted on the output shaft **45** of a gear box **46** driven by motor M2. Needle **42** is shown in its home position in FIGS. **1** and **2** of the drawing. Motor M2 moves needle **42** from the full outline position to the dashed outline position, illustrated in FIG. **2** of the drawing, and then reverses for moving the needle **42** back to the position illustrated in full outline in FIG. **2**.

Referring to FIGS. **1**, **3** and **7** of the drawing, a twister hook assembly **50** comprises a twister shaft **52** rotatably mounted in a bearing **53** having a hook **54** on one end thereof and a pulley **55** on the other end. A drive pulley **56** is mounted on the drive shaft of motor M3 and drives pulley **55** through a belt **58**.

As best illustrated in FIGS. **1**, **2**, **5**, **7** and **14** of the drawing, a ribbon holder-shear assembly, generally designated by the numeral **60**, comprises a holder and shear assembly of the type disclosed in U.S. Design Pat. No. 307,281 to Charles E. Burford and U.S. Pat. No. 4,856,258 entitled WIRE TYING DEVICE, which issued Aug. 15, 1989, to Charles E. Burford and Jimmy R. Frazier. The holder-shear assembly **60** comprises a gripper arm **62** having a gripper finger **64** on one end thereof rotatably secured to a mounting plate **66** by bolt **65**. A pair of anvils **68** and **69** are formed on the end of mounting plate **66**, each being associated with shear surfaces **68***a* and **69***a* to grip and cut a strand ribbon as will be hereinafter more fully explained.

Referring to FIGS. **5** and **7** of the drawing, a cam **70** is mounted on the shaft of motor M4 and is configured to engage cam-followers **72** and **74** on spaced am **71** and **73** secured to and actuating rod **75** mounted for reciprocating movement in bearings **76**. A link **75***a* secures the end of gripper arm **62** to actuating rod **75**.

It should be readily apparent when the shaft of motor M4 rotates one-half revolution, cam **70** will exert force through cam-followers **72** and **74** for moving actuating rod **75** for pivoting the actuating arm **62** about bolt **65**. The free end of the ribbon is gripped between the end of gripper finger **64** and anvil **68** or **69**, depending on which direction the gripper finger **64** is shifted. As will be hereinafter more fully explained, when needle **42** wraps the intermediate section of the ribbon **15** around the gathered neck of a bag, the ribbon will be positioned between gripper finger **64** and the other anvil **68** or **69**. When-gripper finger **64** is shifted to its opposite position, the ribbon will be cut and the free end of the strand of ribbon will be gripped between gripper finger **64** and anvil **68** or **69**.

Referring to FIGS. **12** and **13** of the drawing, roller **41** has a plurality of index points **41***x*. In the illustrated embodiment, the index points are formed by steel dowel pins circumferentially spaced around the axis about which roller **41** rotates.

A proximity switch **41***s* is positioned near index pointers **41***x* for mailing an electrical circuit when the presence of an indexing pin **41***x* is sensed. The proximity switch **41***s* is of conventional design and is connected through a suitable power supply and amplifier to the CPU **96**.

Thus, the CPU monitors the proximity output and counts the pulses produced by index pins **41***x* in roller **41**. The CPU **96** calculates the amount of ribbon dispensed to determine whether or not a bag neck is present as needle **42** moves from the full outline position illustrated in FIG. **2** of the drawing toward the dashed outline position illustrated in FIG. **2** of the drawing. If needle **42** did not wrap ribbon around a bag neck, the CPU will terminate a portion of the remainder of the cycle of operation so that holder-shear **65** will not be actuated to prevent releasing the end of ribbon **15** which is gripped between gripper finger **64** and anvil **68** or **69**.

Referring to FIGS. **1**, **2** and **3** of the drawing, a bag stop lever **80** is mounted on a shaft **85** for rotary movement about a horizontal axis. Shaft **85** extends through an electric brake **82** and has a crank arm **85***a* secured thereto which is resiliently urged in a clockwise direction, as viewed in FIG. **3**, by a spring **83**.

A switch **86** is actuated by switch arm **88**, which actuates a timer for energizing electric brake **82** which momentarily locks bag stop **80** in a fixed position for a predetermined period of time, for example 0.25 seconds for restraining the leading edge of a bag neck, such that gathering belts **22** and **32** will gather the neck adjacent bag stop **80**. At the expiration of the predetermined period of time, electric brake **82** will be de-energized so that linear movement of the bag neck will rotate bag stop **80** upwardly to release the bag so that it will be moved away by the conveyor. Bag stop **80** is biased toward the position illustrated in FIG. **3** of the drawing by a spring **83**. It should be readily apparent that the spring **83** may be replaced by a counter-weight, air cylinder or other suitable biasing mechanism to resiliently urge bag stop **80** toward its home position.

Motors M1, M2, M3 and M4 are bi-directional, permanent magnet, DC brush-type servomotors having outputs proportional to the voltage applied across the armatures. Such motors are commercially available from Groschopp, Inc. of Sioux Center, Iowa as a "Power Master 8304" 24 volt DC continuous power motor. At 1500 rpm the motor generates 16 oz-in torque and has an output of 0.090 horsepower at 4.2 amps. At 2450 rpm the torque is 47 oz-in and the output is 0.113 horsepower at 5 amps. At 5400 rpm the torque is 37 oz-in and the output is 0.197 horsepower at 8.2 amps.

It is noted that other motors and motors of other sizes may be provided to facilitate driving the various assemblies. For example, it is contemplated that smaller motors would be used in a counter top model used for gathering and fastening materials such as coils of electrical cord, water hose, tubing, or yarn, and bundles of cable, rods, or carrots and other produce.

One side of the armature winding of each motor M1, M2, M3 and M4 is connected to ground such that reverting the polarity of current through the armature winding reverses the direction of rotation of the motor.

Each of the motors M1, M2, M3 and M4 has an encoder E1, E2, E3 or E4 mounted on its drive shaft which delivers an electrical signal to a decoder D1, D2, D3 or D4 which is representative of the position of the motor shaft.

Motor Controller

Referring to FIGS. **7** and **8** of the drawing, the numeral **90** generally designates a power supply for delivering electric current to motor controller **91** and to motor M1 in the bag neck gathering mechanism **20**; motor controller **92** and motor M2 in the needle assembly **40**; motor controller **93** and motor M3 in the twister assembly **50**; and motor controller **94** and motor M4 in the holder-shear assembly **60**. Referring to FIG. **8** of the drawing, the power supply **90**

comprises a pair of single-phase, doughnut transformers T1 connected in parallel. The supply or primary circuits of transformers T1 are connectable to any suitable source of electricity such as 115 volt, 60 cycle, single-phase electricity. The energy receiving or secondary circuits of transformers T1 are connected through one or more rectifier bridge circuits B1 and B2 and capacitors C6 and C7 to a pair of controlled voltage power terminals, one of which forms a source of direct current maintained at positive 34 volts and the other a source of direct current at negative 34 volts.

An eight volt direct current power supply is illustrated in FIG. 8 of the drawing. The eight volt power supply comprises a pair of terminals connectable to the positive and negative 34 volt terminals of power supply **90** through resistors R13 and R24 to positive and negative 8 volt terminals. A pair of diodes Zenier D15 and D20 are provided in the 8 volt power supply between resistors R13 and R24 and a ground terminal.

The rectifiers in bridge circuits B1 and B2 are conventional MB 352 rectifiers. Capacitors C6 and C7 are, for example 33,000 UF capacitors. Resistors R13 and R24 are 470 ohm, 2 watt resistors.

The 34 volt and 8 volt power supplies illustrated in FIGS. 7 and 8 are of conventional design and form no part of the present invention except in combination with the other elements of the control circuit. It should be appreciated that many other DC power supplies may be used in lieu of those illustrated in the drawing.

Encoders

Conventional multichannel incremental optical encoders E1, E2, E3 and E4 are mounted on the shaft of each motor M1, M2, M3 and M4, respectively. The encoders E1–E4 are high resolution incremental optical devices which include an encoder body, a metal code wheel and emitter end plate. An LED source and lenses transmit collimated light from the emitter diode through a precision metal code wheel and phase plate into a bifurcated detector lens (not shown).

The light is focused onto pairs of closely spaced integrated detectors which output two square wave signals in quadrature and an optional index pulse.

HEDS-6000 series, two and three channel incremental optical encoder kits are available from Hewlett Packard of Palo Alto, Calif. A standard selection of shaft sizes and resolutions between 192 and 1024 cycles per shaft revolution are available. The part number for a standard two-channel encoder is HDS-6000, while that for the three-channel device, with index pulse, is HEDS-6010. The encoder devices are typically used for printers, plotters, tape drives, positioning tables, automatic handlers, robots, and other servo loop applications. Specific details of construction of the incremental optical encoder can be found in Hewlett Packard Publication No. 5954-8420 (3/87) which is incorporated herein by reference.

The incremental shaft encoder operates by translating the rotation of a shaft into interruptions of a light beam which are then output as electrical pulses. The light source is a light emitting diode collimated by a molded lens into a beam of parallel light. An emitter end plate contains two or three similar light sources, one for each channel.

The code wheel is a metal disc that has N equally spaced slits around its circumference. An aperture with a matching pattern is positioned on a stationary phase plate, The light beam is transmitted only when the slits in the code wheel and the aperture line up; therefore, during a complete shaft revolution, there will be N alternating light and dark periods. A molded lens beneath the phase plate aperture collects the modulated light into a silicon detector.

The encoder body contains the phase plate and the detection elements for two or three channels. Each channel consists of an integrated circuit with two photo-diodes and amplifiers, comparator, and output circuitry (not shown).

The apertures for the two photo-diodes are positioned so that a light period on one detector corresponds to a dark period on the other. The photo-diode signals are amplified and fed to a comparator whose output changes state when the difference of the two photo currents changes sign. The second channel has a similar configuration but the location of its aperture pair provides an output which is in quadrature to the first channel (phase difference of 90°). Direction of rotation is determined by observing which of the channels is the leading waveform. The outputs are TTL logic level signals.

The motion sensing application and encoder interface circuitry will determine the need for relating the index pulse to the main data tracks. A unique shaft position is identified by using the index pulse output only or by logically relating the index pulse A and B data channels. The index pulse can be uniquely related to the A and B data tracks in a variety of ways. Statewidth, pulse width or edge transitions can be used.

The two square wave signals in quadrature of channels A and B and a 5 volt supply input are delivered through a 10-pin connector to a corresponding decoder D1, D2, D3 or D4 mounted on an auxiliary board, as illustrated in FIG. 7 of the drawing. Tines connecting encoders E2 to a decoder D2 are illustrated. Encoders E3 and E4 are similarly connected to decoders D3 and D4.

Decoders

Quadrature decoders D1–D4 are CMOS (complimentary metal-oxide semiconductor) integrated circuits that perform the quadrature decoder, counter, and bus interface functions. "HTCL-2000," commercially available from Hewlett Packard, quadrature decoder/counter interface IC decoder interfaces an encoder to a microprocessor and is designed for use in digital closed loop motion control system and digital data input system.

The decoder includes a 4X quadrature decoder, a binary up/down state counter and a 16-bit bus interface. A Schmitt-triggered CMOS input and input noise filters are incorporated in the device.

Further information regarding the quadrature decoder/counter interface IC for interfacing to Motorola and Intel microprocessors can be found at page 1-61 through page 1-76 of Hewlett Packard Publication for "HCTL-2000," "HCTL-2016," "HCTL-2020."

Decoders D1–D4 have pins for a channel A and channel B Schmitt-trigger inputs which accept the outputs from quadrature encoders E1–E4. The two channels are preferably 90° out of phase.

Controller

The system is controlled by a computer **95**, illustrated in FIG. 6, which receives and stores a set of instructions and then acts upon the instructions in a predetermined and predictable fashion. A microprocessor **96** is attached to a printed circuit board into which a thin layer of metal has been applied and then etched away to form traces. The electronic components of the central processing unit are attached to the board with solder so that they can change electronic signals through the etched traces on the board.

A suitable 32-bit integrated microcontroller **96** is the MC68332 which is commercially available from Motorola, Inc. of Schaumburg, Ill. as a product referred to as "MC68332 SIM" System Integrated Module. A complete documentation package of the MC68332 consists of the (SIM 32UM/AD), *MC68332 System Integration Module User's Manual*, the (CPU32RM/AD), *CPU32 Reference Manual*, and the (TPU32RM/AD), *Time Processing Unit Reference Manual*. The *MC68332 System Integration Module User's Manual* describes the capabilities, register and operation of the MC68332 MCU. The *CPU Reference Manual* describes the operation, programming and instruction set of the CPU32 processor used in the MC68332. The *Time Processing Unit Reference Manual* describes the autonomous timer system used in the MC68332.

The MC68332 microcontroller **96** contains intelligent peripheral modules such as the time processor unit CYPU) which provides 16 microcoded channels for performing time-related activities for simple input capture or output capture to complicated motor control or pulse width modulation. High-speed serial communications are provided by the queued serial module (QSM) with synchronous and asynchronous protocols available. Two kilobytes of fully static standby RAM allow fast two-cycle access for system and data stacks and variable storage with provision for battery backup. Twelve chip selects enhance system integration for fast external memory or peripheral access. These modules are connected on-chip via an intermodule bus (IMB).

The Mc68332 microcontroller **96** is a 132-pin plastic quad flat pack that operates at a frequency of 16.78 MHz with a 5 volt supply and is software programmable. It has 16 independent programmable channels and pins. Any channel can perform any time function including input capture, output compare or pulse width modulation (PWM).

The detailed logical procedures or algorithms processed by the microcomputer are proportional integral derivative (PID) type control mode signals. The PID control mode combines the best action of proportional control, integral control and derivative control in a closed loop control system.

In addition to the microcontroller chip **96** on the CPU board, random-access memory (RAM) integrated circuits **97** are used for storing values in distinct locations which can be recalled or altered for storing the software which controls the system. Since the values which are in RAM memory are lost when the power of the computer is turned off, a battery backup is provided. The microcontroller **96** processes digital signals, such as the presence or absence of voltages, to represent values.

The CPU board is connected to an auxiliary board **98** through a connector header which carries data signals and address signals. Driver circuits C1–C4, which generate pulse width modulated (PWM) signals, are mounted on the auxiliary board along with the decodes D1–D4. The pulse width modulated signals from driver circuits C1–C4 are sent to the motor driven **91–94** selectively delivering positive or negative DC power to control the operation of moron M1–M4.

Closed Loop

The circuits carrying input signals from the encoders El–E4 to decoders D1–D4; the circuit carrying pulse width modulated signals from driver circuits C1–C4 to motor driven **91–94**; and the circuits carrying per from the motor drivers **91–94** to motors M1–M4 form a closed loop control system. The closed loop control system depends upon the feedback concept for operation and the output PWM signals are forced to a pre-assigned function of the reference input of the microcontroller of the central processing unit. The microcontroller **96** sends control PWM signals determined by the programmed movements stored in RAM memory in a pre-assigned order as a function of time after switch arm **88** returns to its home position illustrated in FIG. **3**. The control PWM signals are delivered to the control circuit. Each encoder E1–E4, connected to the shaft of motors M1–M4, send quadrature signals to the decoders D1–D4 that indicate the position of the shaft of each motor. The control PWM signals delivered to each control circuit C1–C4 are delivered to motor drivers **91–94**. The quadrature signals from decoders D1–D4 are read to adjust the control PWM signals.

Drivers **92**, **93** and **94**, which control the delivery of power to motors M2, M3 and M4, respectively, for controlling the needle assembly **40**, twister hook assembly **50** and holder-shear mechanism **60** are substantially identical. One side of the winding of each of the motors M2, M3 and M4 is connected to ground. Drivers **92**, **93** and **94** deliver either positive or negative power to the other side of the motor winding for driving motors M2, M3 and M4 in opposite directions. For example, when positive 34 volt direct current is delivered to the winding of motor M2, its shaft is driven in a clockwise direction. If negative 34 volt direct current is delivered to the winding of motor M2, its shaft will be driven in a counter-clockwise direction.

The driver **91** for motor M1 connected to the bag gathering assembly **20**, is similar to drivers **92**, **93** and **94** except that drier **91** is not provided with the capability of delivering negative direct current because it is not necessary for motor M1 to be driven in reverse.

Software is stored in FEEPROM memory on the CPU board for controlling the acceleration, speed and position of the shaft of each motor M1–M4. FIG. **11** is a graphic representation of the sequence of operation of the needle, hook and shear assemblies during a complete cycle of operation. The microcontroller **96** is initially programmed by a computer through a serial port RS for storing a program which will initiate movement of needle **42** from its home position illustrated in FIG. **3** and the speed of movement toward the dashed outline position illustrated in FIG. **3** controlled by signals delivered through control circuit C2 to motor M2. While needle **42** is moving from the position illustrated in full outline toward the position illustrated in dashed outline, the program causes a signal to be sent from control circuit C3 to motor M3 to begin rotating twister hook **54** and continue rotation of twister **54** a predetermined number of revolutions controlled by the motion profile in RAM memory. Similarly, when needle **42** and twister hook **54** are in predetermined positions, a signal will be sent from driver circuit C4 which will energize motor M4 for rotating cam **70** to move the gripper finger **64** to release the free end of the ribbon and shear a segment from the end of the strand of ribbon. At a time controlled by the software, a signal will be delivered to motor M2 for moving needle **42** from the position shown in dashed outline in FIG. **3** back to its home position. A signal will be delivered to motor M3 for rotating twister hook **54** two revolutions in the reverse direction for slinging the tie, which has been twisted around the neck of a bag, out of the twister hook **54** for completing a tying cycle.

It should be readily apparent that when the neck of a bag moves between gathering belts **22** and **32**, switch arm **88** will be moved downwardly from the position illustrated in FIG. **3** which will energize electric brake **82** so that belts **22**

and 32 will move the neck of the bag into engagement with bag stop 80 causing the neck to be gathered. As the trailing edge of the neck of the bag passes over the end of switch arm 88, switch arm 88 will move back to the position illustrated in FIG. 3 causing switch 86 to send a signal to the microcontroller for starting a new tying cycle.

A schematic diagram of a motor controller 92 is illustrated in FIG. 9 of the drawing. The optic coupler C0 delivers a PWM signal to the positive terminal CH1 from driver circuit C2 with reference to the negative terminal CH1.

The positive terminal CH1 is connected through resistor R14, resistor R15 and diode D11 to the base terminal of high rail MPS651 transistor Q7. The negative terminal CH1 is connected through resistor R18 to the base of 2N2222A transistor Q11 and through a 750 ohm resistor R92 to a negative 8 volt terminal and to the emitter of transistor Q11. A 56 ohm resistor R22 forms a shunt between the base and emitter of transistor Q11. The collector of transistor Q11 is connected between resistors R14 and R15.

The 1 ohm resistor R15 is connected through HMLP1700 diode D13 to the base of low rail MPS751 transistor Q9.

Transistor Q11 turns off and on to turn transistors Q7 and Q9 off and on, which in turn, turn the high rail MJ11033 power transistor Q5 and the low rail MJ11032 power transistor Q13 off and on.

The collector of high rail transistor Q7 is connected through a 300 ohm 5 watt resistor R11 to the base of high rail power transistor Q5. The emitter of high rail transistor Q5 is connected to a +34 volt DC terminal while the collector of power transistor Q5 is connected through an MR822 diode D9 to a line connected to one side of the winding of motor M2. The collector of low rail transistor Q9 is connected through a 300 ohm 5 watt resistor R20 to the base of low rail power transistor Q13. The emitter of low rail power transistor Q13 is connected to a −34 volt DC terminal while its collector is connected through MR822 diode D16 to the line connected to one side of the winding of motor M2.

When the PWM signal, delivered to the terminals marked CH1 is not conducting current, high rail transistor Q7 and high rail power transistor Q5 are turned on for delivering a positive 34 volt direct current to the motor winding causing motor M2 to tend to move in a clockwise direction. When the PWM signal, delivered to the terminals marked CH1, are conducting current, low rail transistor Q9 and low rail power transistor Q13 are mined on for delivering a negative 34 volt direct current to the motor winding causing motor M2 to tend to move in a counter-clockwise direction. The ratio of time in which the PWM signal is in either state determines the direction and speed of the motor.

To protect high rail power transistor Q5 and low rail power transistor Q13 from being conducting at the same time due to differences in manufactured component switching times, high rail inhibit transistor Q17 disables high rail transistor Q7 from turning on as long as low rail power transistor Q13 is turned on.

Likewise low rail inhibit transistor Q1 inhibits low rail transistor Q9 from turning on if there is a positive voltage at the collector of high rail power transistor Q5 sufficient to forward bias low rail inhibit transistor Q1.

The high rail inhibit circuit IH is connected from the collector of the low rail power transistor through diodes D18 and D21 and resistor R29 to the base of high rail inhibit transistor Q17. The emitter of high rail inhibit transistor Q17 is connected to the base of high rail transistor Q7. The low rail inhibit circuit IL is connected from the collector high rail power transistor Q5 through diodes D7 and D5 and resistor R3 to the base of low rail inhibit transistor Q1. The emitter of low rail inhibit transistor Q1 is connected to the base of low rail transistor Q9.

The low rail and high rail inhibit circuits IH and IL assure that the control output voltage be zero before switching occurs. The inhibit circuits protect the power transistors Q5 and Q13.

It is to be understood that while detailed descriptions of a preferred embodiment has been illustrated and described, the invention is not to be limited to the specific arrangement of parts and specific features herein described and illustrated in the drawing. Rather, the descriptions are merely of an exemplary embodiment of the invention, which may be embodied in various forms.

Having described the invention, we claim:

1. Apparatus for securing a bundle of gathered material comprising:

a frame having a slot defining a path;

a shaft secured to said frame;

a stop lever mounted on said shaft for rotary movement about an axis;

an electric brake mounted between said stop lever and said frame;

an electric circuit having a timer connected to said electric brake; and

a switch in said electric circuit, said switch having an arm positioned to extend across said path, said switch, timer and electric brake being connected to momentarily lock said stop lever in a position extending across said path such that material moving along said slot is gathered adjacent said stop lever.

2. Apparatus for securing a bundle of gathered material according to claim 1 with the addition of a source of ribbon;

a holder-shear assembly for cutting the ribbon and gripping the free end of said ribbon;

a pulley engaging said ribbon between said source of ribbon and said holder-shear assembly;

a proximity switch adjacent said pulley; and

a needle engaging said ribbon between said pulley and said holder-shear assembly, said needle being configured for wrapping the ribbon around material gathered adjacent said lever, said proximity switch being mounted in a circuit configured to indicate when the ribbon has been wrapped around gathered material adjacent said lever.

3. Apparatus for securing a bundle of gathered material according to claim 1, said shaft extending through said electric brake such that movement of said stop lever is restrained when said electric brake is energized.

4. Apparatus for securing a bundle of gathered material according to claim 3, said timer being electrically connected between said electric brake and said switch for de-energizing said electric brake at the expiration of a predetermined period of time after said electric brake has been energized.

5. Apparatus for securing a bundle of gathered material according to claim 3, with the addition of a biasing mechanism connected between said shaft and said frame to resiliently urge said bag stop toward a predetermined home position.

6. Bag neck tying apparatus comprising:

a frame having a slot defining a path;

a source of ribbon for dispensing a strand of ribbon having a free end and a central portion;

a holder-shear assembly on said frame for cutting the ribbon and holding the free end of said ribbon;

a needle assembly movably secured to said frame for engaging and positioning said central portion of said ribbon adjacent said holder-shear assembly;

a twister assembly movably secured relative to said frame having a hook adjacent said holder-shear assembly;

a bag stop lever mounted on said frame;

biasing means mounted between said frame and said bag stop lever for resiliently urging said bag stop lever toward a home position extending across said path;

an electric brake for locking said bag stop lever in said home position such that a bag neck moves into engagement with said bag stop lever for gathering material;

a timer for energizing said electric brake to momentarily lock said bag stop in said home position and to de-energize said electric brake at the expiration of a predetermined time period;

a plurality of electric motors, said electric motors having drive shafts connected to each of said holder-shear assemblies, needle assembly and twister assembly;

encoders connected to each said electric motor for generating electrical signals related to the position of each said drive shaft;

a closed loop control circuit connected to said motor and to said encoder; and

a controller connected to said closed loop control circuit for controlling each of said electric motors to synchronize movement of each of said assemblies relative to each of the other assemblies.

7. Bag neck tying apparatus according to claim **6**, with the addition of a proximity switch associated with said source of ribbon and said controller to prevent movement of said holder-shear assembly if said needle assembly has failed to wrap the ribbon around a bag neck.

8. Bag neck tying apparatus comprising:

a frame;

a source of ribbon for dispensing a strand of ribbon having a free end and a central portion;

electrically driven holder-shear assembly for cutting the ribbon and holding the free end of said ribbon;

a needle assembly for engaging and positioning said central portion of said ribbon adjacent said holder-shear assembly;

a material gathering assembly for gathering material, said gathering assembly being positioned adjacent said holder-shear assembly;

a twister assembly movably secured relative to said frame having a hook adjacent said holder-shear assembly;

a switch having an arm positioned to be engaged by material moved by said material gathering assembly;

a stop lever mounted on said frame;

an electric brake connected to said switch and to said stop lever for momentarily locking said stop lever in a home position such that material is gathered adjacent said lever when said brake is energized;

a timer connected to said switch and said brake for de-energizing said brake after expiration of a predetermined period of time; and

a proximity switch adjacent said ribbon in an electrical circuit connected to said electrically driven holder-shear assembly to prevent actuation of said holder-shear assembly if said needle assembly fails to pull ribbon from said source of ribbon to wrap ribbon around gathered material adjacent said twister assembly.

9. Bag neck tying apparatus according to claim **8**, said holder-shear assembly comprising:

a mounting plate;

a gripper arm;

a gripper finger on one end of said gripper arm;

means for rotatably securing said gripper arm to said mounting plate;

a pair of anvils on said mounting plate, each of said anvils being associated with shear surfaces to grip and cut a strand of ribbon positioned between one of said anvils and said gripper finger; and

an electric motor drivingly connected to said gripper arm for moving said gripper finger to cut and grip said ribbon.

10. Bag neck tying apparatus according to claim **8**, said needle assembly comprising:

a needle;

an idler roller on said needle;

an electric motor having an output shaft; and

a gearbox drivingly connecting said needle to said motor output shaft.

11. Bag neck tying apparatus according to claim **8**, said source of ribbon comprising:

ribbon on a spool routed around at least one pulley such that said pulley rotates if ribbon is pulled from said spool;

a plurality of index pointers on said pulley;

a proximity switch positioned near said pulley for making an electrical circuit to output pulses when the presence of an indexing pointer is sensed; and

a CPU connected to said proximity switch to monitor the proximity switch output and count pulses produced by said index pointers, said CPU calculating the amount of ribbon dispensed to determine whether or not a bag neck is present as said needle assembly moves toward said holder-shear assembly.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 5,708,339

DATED : January 13, 1998

INVENTOR(S) : Jimmy R. Frazier, John D. Richardson & Greg P. Coxsey

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, line 18, change "Charles C Burford" to read --Charles E. Burford--.

Column 5, line 38, change "secured to and" to read --secured to an--.

Signed and Sealed this

Tenth Day of November 1998

Attest:

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks